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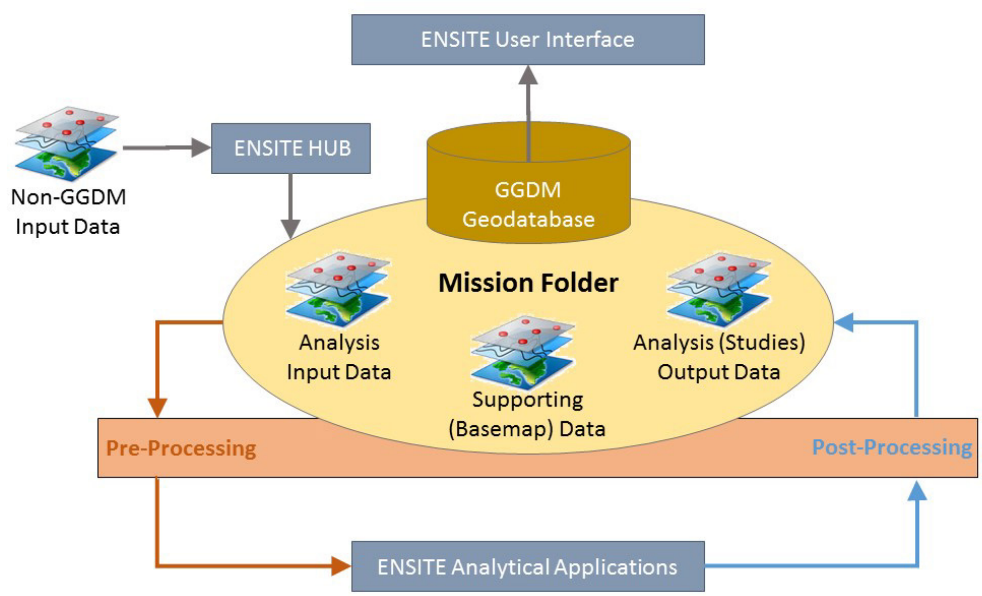
Engineer Site Identification for the Tactical Environment (ENSITE)

Data Collection and Management with ENSITE HUB

ENSITE HUB Version 1.0

Juliana M. Wilhoit, Natalie R. Myers, and George W. Calfas

August 2017



Construction Engineering Research Laboratory

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Final report

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Prepared for Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA(ALT))
103 Army Pentagon
Washington, DC 20314-1000

Under Project 455009, “Contingency Base – Site Identification for the Tactical Environment”

Abstract

The current military environment means the U.S. Army needs the capability to strategically site contingency bases (CBs) for rapid response throughout a joint area of operations. To help with this need, the Army is funding work in the Engineering Site Identification for the Tactical Environment (ENSITE) program, which develops data and knowledge capabilities to assist decisions for CB site locations. Critical to the ENSITE program is the capability to integrate geospatial data elements in ways that broaden and improve military planners' understanding of the operating environment. To address this concern, ENSITE HUB is the set of tools developed for collecting, processing, and storing the various geospatial data required to execute ENSITE's analytical tools. The end product of the ENSITE HUB workflow is a mission folder, which is a transportable folder following a consistent structure. This report provides a temporal snapshot of the ENSITE HUB software and process.

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Preface

This study was conducted for the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA(ALT)) under Program Element T45, Project 455009, "Contingency Base – Site Identification for the Tactical Environment." The technical monitor was Mr. Kurt Kinnevan.

The work was performed by the Environmental Processes Branch (CNE) of the Installation Division (CN), U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL). At the time of publication, Mr. H. Garth Anderson was Chief, CEERD-CNE; Ms. Michelle Hanson was Chief, CEERD-CN; and Mr. Kurt Kinnevan CEERD-CZT, was the Technical Director for Adaptive and Resilient Installations. The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti, and the Director was Dr. Ilker Adiguzel.

The Commander of ERDC was COL Bryan S. Green, and the Director was Dr. David W. Pittman.

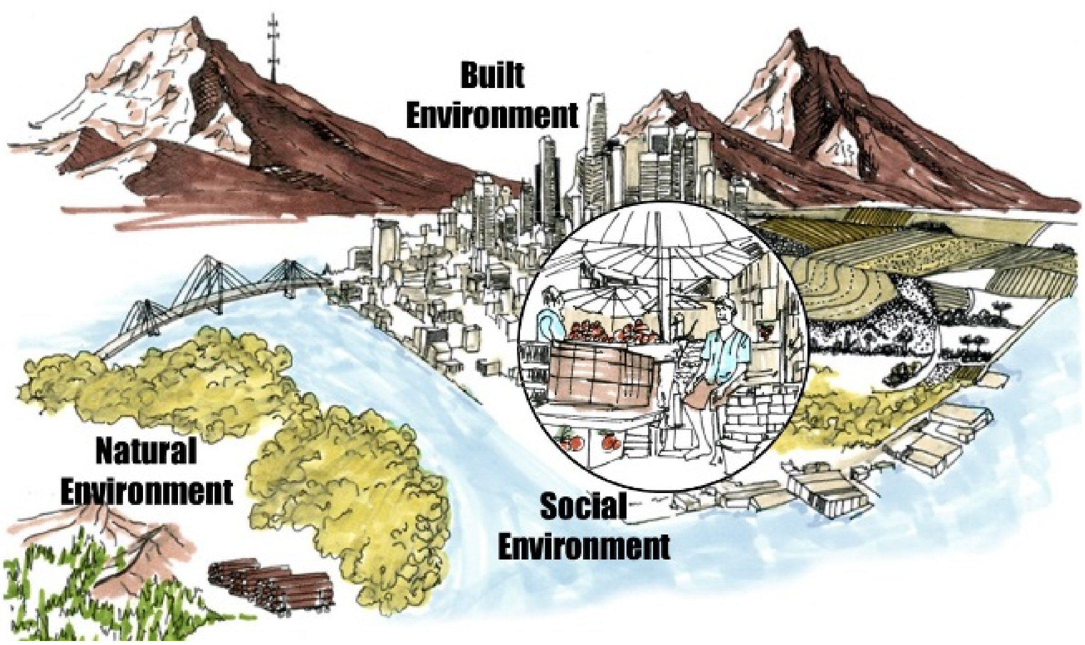
1 Introduction

1.1 Background

The Engineer Site Identification for the Tactical Environment (ENSITE) program is dedicated to empowering military planners with the data and knowledge for siting contingency base (CB) locations. The program is sponsored by the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA(ALT)) with a funding timeline of October 2015 to September 2018. Figure 1 depicts the areas of research for the ENSITE research program.

CB locations and designs are not one-size-fits-all; rather, they should be viewed as a multilayer decision process to support the mission and commander's intent. The built, ecological, and sociocultural environments impact military bases and, in turn, bases affect those environments. Failure to understand these effects may result in increased logistical burdens and unintended consequences on local populations and natural resources—negatively impacting the military mission.

Figure 1. Overview of environments that are visualized and integrated as part of the ENSITE process.



ENSITE provides military planners with the ability to integrate and visualize data of the built, natural, and social environments to support site analysis. ENSITE builds upon leading geospatial platforms already in use by the Army (including ESRI ArcMap®) to offer an easy-to-use, customized set of workflows that remotely evaluates the built, natural, and social environment characteristics of a location in support of siting CBs. ENSITE combines Army doctrine, open-source data, and authoritative Army data in conjunction with user input to execute automated processes capable of processing large amounts of data in a rapid, consistent, and standardized manner.

With such a tool, CB planners (as well as designers, operators, and managers) can rapidly assess possible current and future situations to provide proactive operational control and timely alternative situational analyses while they are deployed or as part of their training programs.

ENSITE's software capability supports the full life cycle of the base—from design, construction, and operations/management, to deconstruction—with software components that add specific functions and features while minimizing complexity for the end user. ENSITE is constructed as a collection of software components ("plug-ins") developed to answer the following questions:

- What resources and infrastructure are locally available?
- Are operations likely to affect the life patterns of the local population?
- Where will the construction of a base camp best leverage local resources and minimize social impacts?
- How do we build a base camp for a specific intent as well as for a sustainable lifecycle?

1.2 Objective

This report outlines the general resources, data standards, and file structures that make up the process by which data is collected, managed, and utilized in the ENSITE software, particularly through the semi-automated data collection process referred to as ENSITE HUB.

1.3 Approach

Within this report, Chapter 2 provides an overview of the data architecture. It defines the data standards and describes how data is collected, stored, and utilized via a workflow chart. Chapter 3 details ENSITE HUB, ENSITE's semi-automated data collection process that gathers geospatial data from various sources and processes them so that they can be ingested by ENSITE. Chapter 3 provides detailed execution instructions for ENSITE HUB. Chapter 4 concludes with discussion of future improvements.

1.4 Scope

This report is noted as version 1.0 because it was completed at the midway point in the ENSITE development effort. It is anticipated that provisions within this report will be updated as the Army's needs and the ENSITE program evolve. Thus, additional updates of this report (version 2.0, etc.) are anticipated.

2 Data Architecture

A data architecture creates a common operating environment for software by setting data standards and describing how data is collected, stored, and utilized. The Army recognizes that the collection, management, and analysis of data has significant effects on mission effectiveness. The Army and the National Geospatial-Intelligence Agency (NGA)* work together to develop and maintain databases that support Army Geospatial Information and Services (GI&S). Army geospatial units and activities develop their geospatial databases in accordance with the Ground-Warfighter Geospatial Data Model (GGDM) standards. The Army Geospatial Enterprise (AGE) is where the standardized geospatial information is collected, managed, analyzed, visualized, and disseminated across the Army. The "AGE is a distributed SSGF [Standard Sharable Geospatial Foundation] database and supporting infrastructure that is based on a common suite of interoperable software" (Army Technique Publication [ATP] 3-34-80). ENSITE abides by the AGE SSGF in support of the Army's Common Operational Picture.

2.1 Data standards

ENSITE synchronizes with the Army's geospatial data standard—GGDM. GGDM was developed from the National System for Geospatial-Intelligence (NSG), a comprehensive framework developed by NGA. The GGDM schema comprises elements of the NSG relating specifically to ground warfighting; for example elements related to ocean navigation are excluded. The GGDM helps to eliminate stovepipes, reduce costs, simplify acquisition and accelerate transition of technology as part of a SSGF. The data model is the ground-warfighter "container" into which geospatial data elements are collected, managed and used for analysis. It provides a mechanism for storing and sharing ground-warfighter specific feature data across multinational ground forces.

A roadmap is underway for transitioning Army ground-warfighter systems and geospatial data to the GGDM. U.S. Army Geospatial Center (AGC), Distributed Common Ground System-Army (DCGS-A), and other Army

* NGA is the lead federal agency for geospatial intelligence (GEOINT) and manages a global consortium of more than 400 commercial and government relationships. NGA is a unique combination of intelligence agency and combat support agency. It is the world leader in timely, relevant, accurate and actionable GEOINT. (www.nga.mil/About/)

and U.S. Marine Corps (USMC) geospatial datasets and systems are transitioning to the GGDM. Future versions of the GGDM may include additional ground forces enterprise content that include high-resolution urban information, additional aeronautical information, modeling and simulation, tactical information, and updates based on common geospatial data requirements across ground force components.

Geospatial data is the foundation for the U.S. Army Acquisition Support Center's (USAASC)[*] Common Operating Picture (COP). The establishment of a common vocabulary enables consistent management and sharing of feature data generated by national agencies, army, and other services organizations. The U.S. Army Corps of Engineers' AGC is the focal point for the AGE. AGC is responsible for providing the standards and technology to acquire, manage, and share geospatial data for the warfighter.

2.1.1 Naming conventions

GGDM dictates naming conventions for naming geospatial data to allow useful information to be deduced from the names based on regularities.

2.1.1.1 Vector data

Vector data located within ENSITE's GGDM-compliant database will conform to the GGDM schema. This schema includes both the names for feature classes and the possible field values. For vector datasets which fall outside the scope of GGDM (i.e., networked datasets, spatial nodes of attraction, or space syntax), the following standards are used (adapted from Boone County 2008).

- Title Case is preferred for readability.
- No special characters are permitted with the exception of underscore (_).
- The number of characters comprising a Feature Class name is unlimited; however, brevity is preferred.
- Names should be in stated in singular form, rather than plural.

[*] USAASC supports the program executive offices in the areas of human resources, resource management (manpower and budget), program structure, and acquisition information management. (http://asc.army.mil/web/organization)

- Static feature classes with a yearly vintage must indicate the compilation circa as a 4-digit suffix to the feature class name (e.g., ZoningPermits1990).
- Static feature classes with a monthly compilation period must have a suffix consisting of a 4-digit year followed consecutively by a 2-digit month (e.g., ZoningPermits199903).

2.1.1.2 Raster data

Because of the variety of scales and specifics of rasters, there is not a general standard for naming rasters. The NSG Application Schema (NAS) does not outline conventions for rasters nor does the Department of Defense (DoD)-sponsored Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE). The SDSFIE website, however, provides a set of "in-progress" best practices for all forms of raster data (imagery, elevation, etc.), and contains a compendium of raster and related standards that are considered most applicable for Installation Geospatial Information and Services (IGI&S).*

Following these best practices, ENSITE's convention for naming rasters is to preserve their name from the original source. For example, one of ENSITE's basemap layers is a digital elevation model (DEM). This is acquired from AGC's Common Map Background (CMB), with the filename "CMB_ELV_SRTM2" so ENSITE's DEM uses that name. ENSITE's stakeholder engagement with Army's Geospatial Planning Cells (GPCs) indicates that geospatial users are often familiar with source names. Additionally, preserving these names makes tracking source data and metadata easier. One limitation of this is that ESRI geodatabases do support names longer than 13 characters for raster's stored as an ESRI grid; therefore, some names may be truncated.

2.1.2 Metadata

Metadata provides information about data and is an essential component of documenting geospatial data. As part of the data governance and review process, metadata is established for each data source. All data must follow

* https://www.sdsfieonline.org/Standards/Raster

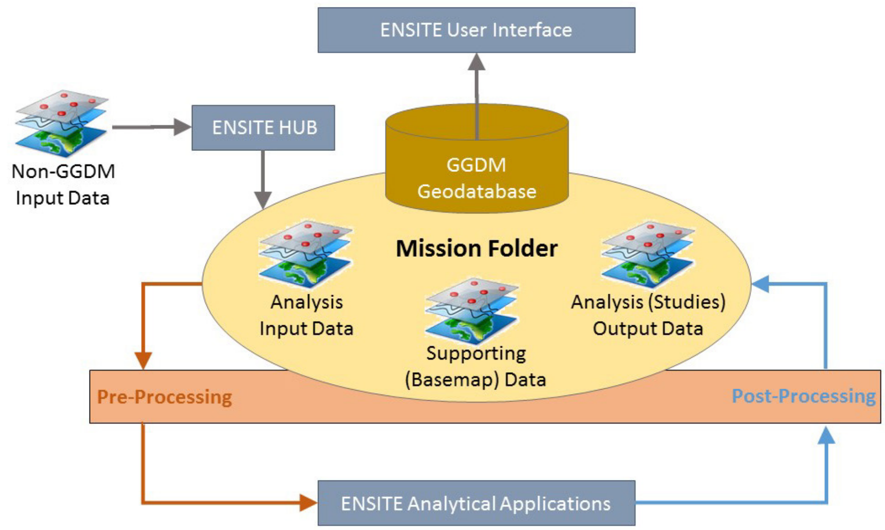
a specific template and answer specific questions about data source, limitations, and justifications for inclusions. Examples of metadata for ENSITE can be found in Section 2.6, “Input data.”

2.2 Data structure

In the endeavor to be flexible and light, ENSITE users must configure the software for their area of interest and mission. In other words, global data does not come pre-loaded. Users must load their own data. That data is structured and managed in a way that it is interoperable and scalable. So once data has been established for an area of interest, it is shareable and its outputs are also sharable/merge-able (i.e., SSGF).

Figure 2 provides a graphic representation of the ENSITE data structure and workflow. As shown, data feeds a geodatabase that analytical applications (i.e., plug-ins) draw from. The ENSITE user accesses a user-interface to run and visualize analyses. Outputs can be saved to the internal geodatabase. The data/geodatabase is housed in what is referred to as the Mission Folder. The Mission Folder contains data for a specific area of interest. A user, for example, may create a Mission Folder for Dhaka, Bangladesh and another for Manila, The Philippines. The analytical applications are universal. The applications are discrete packages of code that run consistently on any Mission Folder geodatabase. The challenge is that not all data that is needed to run the analytical applications are organized according to GGDM standards. ENSITE HUB is a semi-automated conversion process. Users acquire the necessary data and then run it through ENSITE HUB’s tools and populate the Mission Folder with the data. Thus, analysis input data is most commonly generated through ENSITE HUB. Supporting data is often preloaded or obtainable from ENSITE managers. Analysis output data is generated from running specific analytical applications to the input data.

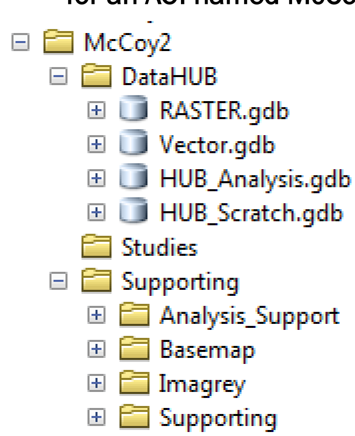
Figure 2. ENSITE data model for structure and workflow.



2.3 The Mission Folder

The format of the Mission Folder structure is fixed to allow for consistent development across mission areas. The Mission Folder segregates data based on type. This is because GGDM is a vector standard, and the database must be modified to include raster data. The root of the Mission Folder contains three components that hold the inputs to ENSITE: (1) "Data HUB" to contain the ENSITE HUB outputs/analysis input data; (2) "Studies" to contain analysis outputs; and (3) "Supporting" to contain basemap features. Figure 3 provides a screenshot of the Mission Folder for an area of interest (AOI) named McCoy.

Figure 3. Screenshot of the Mission Folder and subfolders for an AOI named McCoy2.



2.3.1 The Data Hub Folder

The Data Hub Folder contains both intermediate data (held in scratch.gdb) and analyses that will eventually feed into ENSITE. There are four geodatabases in the folder: ENSITE_RASTER, ENSITE_VECTOR, HUB_Scratch.gdb, and HUB_Analysis

1. **ENSITE_RASTER** is a geodatabase that contains raster data. Raster data currently used in ENSITE are all available from the AGC's CMB, and the current structure in ENSITE preserves the naming conventions used in CMB.
2. **ENSITE_VECTOR** is a geodatabase that holds the vector data in a GGDM-compliant format. The database contains all of the data in a feature dataset, which is named for the scale of the input feature data (ranging from global to local). ENSITE is constructed using the features available at the GGDM's local level. However, it is recognized that there may be a user workflow in which data is available at the regional level. As further research is done on user workflows, plug-ins will be developed that have a variable for the feature dataset name.
3. **HUB_Scratch** is a file geodatabase (.gdb) and the default location for storing intermediate data for products produced in HUB. A user is unlikely to need to go into the scratch.gdb unless they are troubleshooting. The intermediate contents for ENSITE analytical analyses are stored in a separate geodatabase.
4. **HUB_Analysis** is a geodatabase that contains the output of an analysis conducted in ENSITE HUB that is ready for being ingested in ENSITE but does not seem to fit elsewhere within the structure. This folder contains vector data that cannot be mapped to the GGDM standard (i.e., networked datasets, spatial notes of attraction, and space syntax).

2.3.2 Studies Folder

The Studies Folder contains the analysis outputs from analytical applications. Each time an application is run, a new folder is created that contains all of the results. These folders will be given consistent names following the structure: Mission Folder Name_MGRS_TimeStamp. (MGRS is the abbreviation for Military Grid Reference System.) An example of a folder name would be "Nairobi_37MBU55_27Oct2016." While including the Mission Folder name is a bit redundant because all of the analyses will share the same first section, this consistent naming schema allows for consistent sharing of the data produced. There are three elements within this folder, which mirror the inputs and resulting folders of DataHub (refer to Figure 2), as listed below:

1. **S_MGRS_TimeStamp_Raster** contains the outputs to analytical analyses that are raster. [*]
2. **S_MGRS_TimeStamp_Vector** contains the outputs of analytical analyses that are GGDM compliant. Every effort should be made to make vector data GGDM compliant.
3. **S_MGRS_TimeStamp_Analysis** contains non-GGDM compliant vector data analytical analysis outputs.

It is important to note that no global data is included in the Studies Folder. If a study is run on one small neighborhood in Dhaka, then only the data for that one area will be output. Most importantly, data produced in ENSITE HUB and stored in the DataHub\Hub_Analysis Folder will not be included in the Studies Folder, an exclusion that may be confusing when sharing results of work done in ENSITE analysis because a user may expect the data they are sharing would include all of the foundational data. One solution would be to create a "package data" option within CB_SITE to gather the inputs (DataHub) and outputs (studies).

2.3.3 Supporting Folder

The Supporting Folder contains data to support analysis in ENSITE. This folder is likely the one that will expand the most over the life cycle of the ENSITE research and development effort. Currently there are three subfolders, as outlined below:

1. **Analysis_Support** contains tables which are used in later analysis and related to data that is produced in ENSITE HUB. For example, the table "MAAX_U_soils_table.csv" relates Army doctrine about soils that is contained in FM 5-472 (2001) to the soil data in the MAAX_U_SoilScape raster. By containing this linked information within a comma-separated values (.csv) file (rather than code), it can be more easily updated.

[*] A prefix of "S" was added to these databases because the best practice is to not start a geodatabase name with a numeral.

2. **Basemap** contains three shapefiles which are used in the current iteration of ENSITE to produce a basemap. These basemap files are produced in ENSITE HUB. Future versions of ENSITE should be able to ingest rasters, making this folder obsolete.
3. **Imagery** contains imagery basemaps.

ENSITE HUB is the name given to a set of tools developed for taking the various data collected by ENSITE's analytical tools and user interface and then, becoming the hub that processes the collected data for ingestion by ENSITE (i.e., organizing the data collected according to GGDM standards). Specifically, ENSITE HUB is a series of tools developed by the ENSITE team, using ArcGIS® Model Builder and Python® scripts that process the data for GGDM compliance. All the data produced in ENSITE HUB is fed into the Mission Folder for a particular mission's AOI. A user with moderate GIS experience is expected to go from data collection to a completed Mission Folder in a few hours.

2.4 ArcMap tools

ENSITE HUB is currently a set of three tools within the desktop application ArcMap. These tools listed below take data derived from a variety of sources and compile it for the mission folder:

1. **Convert_CMB_to_ENSITE** is a tool that takes raster data supplied by the AGC's CMB as raster catalogs, adds the appropriate raster prefix, and stores the data as an ESRI grid.
2. **OSM_to_GGDM** is a tool that takes data from OpenStreetMap® (OSM) and extracts water, roads, and railroads into the GGDM compliant format.
3. **No_Build_Culture** is a tool extracts cultural sites identified as protected sites through the Hague and Geneva conventions. These areas are marked as no-build in ENSITE.

2.5 Data governance

The analysis in ENSITE is only as good as the underlying data. Before underlying data is incorporated into ENSITE, it is vetted and documented by the ENSITE research team. While initially cumbersome, this process benefits the ENSITE program by:

- providing transparency and accountability;

- ensuring key stakeholders are engaged in the decision process;
- ensuring documentation and integration from the outset; and
- preventing the use of non-authoritative data sources in analysis.

2.6 Input data

This subsection provides the data governance documentation for all data currently within ENSITE.

2.6.1 Digital Terrain Elevation Data (DTED) Level 2

Data Overview	Product summary	Digital Terrain Elevation Data (DTED) is a product derived from the Shuttle Radar Topography Mission (SRTM), done in conjunction with NASA to create the first near-global set of land elevations. The DTED product represents a matrix of measured elevation posts over a portion of the earth's surface which are based on degree cells. DTED elevations are in meters, rounded off to the nearest whole meter. DTED Level 2 consists of 1 arc-sec data (approximately 30 m), which is roughly equivalent to the contour information contained on a 1:50,000 scale topo map. The SRTM in 2000 collected 80% of the earth’s surface at this resolution, and DTED-format datasets are becoming increasingly available.[*] The void-filled version of the product (used in ENSITE) contains estimations of elevations for the 20% of the earth’s surface not captured in the initial SRTM collection. NGA filled the voids by using interpolation algorithms in conjunction with other sources of elevation data. Most voids are filled with elevation data from the ASTER GDEM2 (Advanced Spaceborne Thermal Emission and Reflection Radiometer Global Digital Elevation Model Version 2).[†]
	Product source	NGA via the CMB
	Update frequency	Static; last release 2001
	Product coverage	Global, with some holes; for example, oceans are not included.

[*] More info: https://www.nga.mil/ProductsServices/TopographicalTerrestrial/Pages/DigitalTerrainElevationData.aspx

[†] Source: http://www2.jpl.nasa.gov/srtm/

	Product resolution	1-arc second, approximately 30 meters
	Source format	Via CMB, the format is raster catalog
	Source projection	WGS84
	Classification/ distro restrictions	LIMDIS
Data Meaning and Context	Use within literature	SRTM data is used widely within academia and is considered to be a reputable datasource for elevation. An analysis of STRM data points collected by using the Global Positioning System (GPS) in the Catskill Mountains (New York, USA) and Phuket (Thailand). The analysis found average differences in elevation ranging from 7.58 ± 0.60 m in Phuket and from 4.07 ± 0.47 m in Catskills (mean ± S.E.M. [standard error of the mean]). This range is significantly better than a standard SRTM accuracy value indicated in its specification (i.e., 16 m; Gorokhovich and Voustianiouk 2006)
	Justification for source	The DTED product is the most easily accessible elevation product available to our user base. The global coverage (and void-filled coverage) makes this product globally reliable.
	Other products evaluated	ASTER DEM was evaluated.* This product was not selected for use in ENSITE because the product's unique benefits were unclear, and it was not available through the CMB. Instead, a product available through the CMB was chosen because CMB availability allows easy distribution.
	Data product limitations	• The product's resolution is 1 arc-second and since some areas are void-filled for location-specific analysis, other more precise datasets (such as LIDAR) should be used. • The SRTM data has an accuracy of 16 m.

* https://asterweb.jpl.nasa.gov/gdem.asp

2.6.2 Oceans and Lakes

Data Overview	Product summary	Certain analyses in ENSITE require knowing the location of water features. Large water features including large lakes and oceans are not included in the OSM database, which is otherwise relied on for small inland water features. To rectify this issue, the Global Lakes and Wetlands Database (GLWD) from the World Wildlife Fund and the OSM Oceans dataset were merged.
	Product source	Developed by Juliana Wilhoit
	Update frequency	Static
	Product coverage	Global
	Product resolution	Small – includes features with an area of .01 km^2.
	Source format	Shapefile, polygon
	Source projection	WGS84
	Classification/ distro restrictions	None
Data Meaning and Context	Necessity of dataset	Global datasets do exist for global water bodies (including oceans). However, these datasets do not match the spatial resolution (which can vary) in OSM. Currently, a raw extract of OSM does not contain the ocean, as that is technically not a mapped element. Coastlines are mapped, but oceans are not. Therefore, to ensure that there was contiguity between the foundation data produced using OSM data, a global oceans file produced using coastlines was used. Furthermore, researchers discovered that some other large waterbodies also were not included in OSM extracts. As a result, it

		was necessary to ensure that these large water bodies were included by relying on the GLWD. A new dataset was created to reduce processing times.
	Justification for source	**Ocean Polygons**: OSM includes a map of coastal features, but not of large water bodies. This dataset includes bodies of water that are bounded by a coastal area tagged as "natural=coastline."* This dataset is updated weekly. However, given that few sites are likely to change, researchers determined that it would improve the user experience and reduce processing times to have a static file. **Global Lakes and Wetlands Database (GLWD)**.† This dataset was developed by the World Wildlife Fund and the Center for Environmental Systems Research, University of Kassel, Germany. It represents permanent open bodies of water which are greater than .01 km^2. The dataset was developed in 2003 and has been recognized as an authoritative source of water features. The product may be limited by its age, however, since water features may change shape, size, or existence given climatic and population demands.
	Other products evaluated	Evaluated global ocean dataset, but there were some differences in the coastline present between that dataset and OSM. Using the OSM dataset further ensures that some large water features (like Lake Victoria) are captured which are not present as a polygon feature in the OSM data, but are mapped through their coastlines.
	Data product limitations	The dataset is static, based on a representation of OSM coastlines in August 2016. As OSM edits occur to the coastline and coastal features, there may be a incongruity between these.

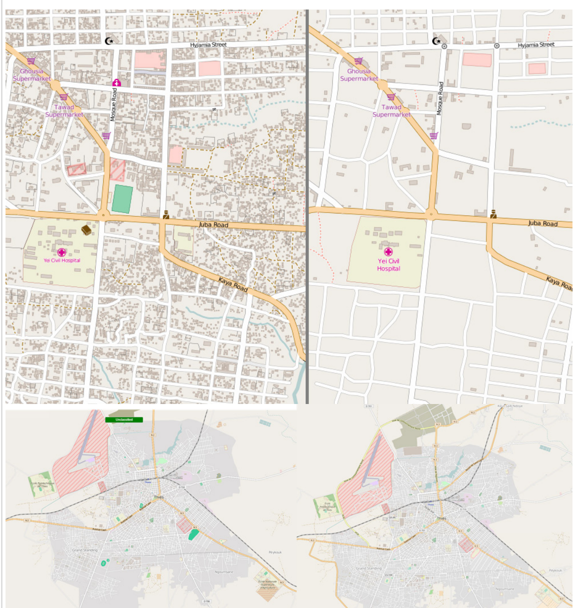
* http://openstreetmapdata.com/data/water-polygons

† http://www.worldwildlife.org/pages/global-lakes-and-wetlands-database

2.6.3 OpenStreetMap

Data Overview		
	Product summary	OSM is a global mapping platform using volunteered geographic information to create a free and editable map of the world. Started in 2004 in the UK, OSM has grown to having over 2 million users who contribute data. OSM values local knowledge and "OpenStreetMap emphasizes local knowledge. Contributors use aerial imagery, GPS devices, and low-tech field maps to verify that OSM is accurate and up to date."* Unlike other projects, the map is not viewed as the primary product; it is instead the underlying data.
	Product source	The Open Street Map Foundation via MapZen extracts.† Due to limitations on file types and download sizes directly from the Open Street Map Foundation site, ENSITE uses a mirror server hosted by MapZen. This server allows users to select the area they wish to obtain data for and then download it as a shapefile.
	Update frequency	Weekly. New versions of the OSM database are published weekly with a change file on Sundays.
	Product coverage	Global, with details varying on the location.
	Product resolution	N/A
	Source format	Raw data from OSM is provided as a .osm which is an XML format. Data from MapZen are point, line, and polygon shapefiles.
	Source projection	WGS84
	Classification/ distro restrictions	None

* https://www.openstreetmap.org/about
† https://mapzen.com/data/metro-extracts

Data Meaning and Context	Use within literature	OSM is widely becoming a standard dataset for academics and practitioners.
	Justification for source	OSM provides an invaluable initial step for assessing the urban environment globally at the UNCLASS level. The dataset is not comprehensive, and there are differences in quality depending on location. However, the depth of data, the ease of use, and its growing adoption by the DoD and academic communities demonstrates its weight. For example, OSM is the base of the NGA project MapEdit. MapEdit builds on a snapshot of the OSM database from 2016 and allows the Intel Community to add data for areas of interest. These edits are published to the MapEdit database and not viewable by those outside the DoD. Additionally, MapEdit data can be exported in accordance with the DoD Standard Schema called the Topographic Data Store (TDS). For many areas of the world, local mapping efforts have added additional data since the initial OSM snapshot was taken. Unfortunately, this additional data makes it seem that all-too-important information about the military operational environment is missing in OSM.  Example: Thies, Senegal. MapEdit (L) and OSM (R). The OSM displays more current data and has a greater level of detail including additional streets

	Other products evaluated	Wikimapia was pursued as an additional data source.* Unlike OSM, Wikimapia perceives the main output to be the map itself, which results in a more difficult experience to download data. Additionally, Wikimapia does not have as large a user community, meaning that its data are more sparse.
	Data product limitations	• Accuracy- As the means of data collection differ (handheld GPS, satellite imagery, "Walking Papers"†), the spatial locations of sites may differ slightly from surveyed locations and as a result "each contribution follows its own level of detail standards" (Touya 2012). A study done of OSM in 2010 in the UK that matched OSM data and the government ordinance survey, found a 6 m difference between OSM-identified locations and the surveyed locations (Hacklay 2010). A study of OSM conducted in France found greater issues with the quality of the data (Girres and Touya 2010). Another study looking at building footprints in Munich, Germany, shows "that OSM footprint data in Munich have a high completeness and semantic accuracy" (Hongchao et al. 2014). • Non-Authoritative Source – While OSM is considered to be an invaluable source for the ENSITE team, it is not considered an authoritative data source by the DoD. Because of this, all OSM data for ENSITE use is converted so that it follows the GGDM, which is the Army standard. This conversion allows future swap-in of an authoritative data source without having to change ENSITE analysis procedures.

2.6.4 SoilScape

Data Overview	Product summary	The SoilScape Unified Soils Classification System Layer (Usoils) provides information on soil type based on the Unified Soils Classification System (USCS), which is an engineering properties-based system. Attribution includes a two-letter soils identifier and a brief text description of the soil type.

* http://wikimapia.org/

† Walking Papers provides the option of an A4-size printout of an OSM map and then, it allows user annotations to be scanned so that new features can be added to OSM. (http://wiki.openstreetmap.org/wiki/Walking_Papers).

	Product source	NGA via CMB
	Update frequency	Static
	Product coverage	Near global
	Product resolution	30 m, with a 90-m minimum mapping unit (MMU)
	Source format	Raster
	Source projection	WGS84
	Usage limitations	LIM DIS// FOUO
	Classification/ distro restrictions	None
Data Meaning and Context	Use within literature	No articles citing this data source were able to be found. This is due in part to the fact that this data source originates from within the intelligence community.
	Justification for source	This soil dataset is considered to be the foundation dataset by NGA. This means that other NGA products are built off this dataset.
	Other products evaluated	None, because this product is considered to be the authoritative source and it has near-global coverage.
	Data product limitations	One of the limitations of the product is that there is limited information available on the data source.

2.6.5 UNESCO

Data Overview		
	Product summary	This dataset is from the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage program and contains the coordinates for these sites. UNESCO sites are selected as having global significance to culture, science, or history. UNESCO World Heritage sites are protected by international treaty.* There are currently 1,052 sites globally. This list includes the three categories of sites, as follows: cultural, natural, and mixed.
	Product source	UNESCO World Heritage Program†
	Update frequency	Annual
	Product coverage	Global
	Product resolution	N/A; it is the center of the site
	Source format	.csv with coordinates for sites
	Source projection	WGS84
	Classification/ distro restrictions	None

* Source: http://whc.unesco.org/en/criteria/.

† http://whc.unesco.org/en/syndication

Data Meaning and Context	Use within literature	The UNESCO World Heritage Sites are a global dataset. This dataset is used both for research and policy making.
	Justification for source	The UNESCO World Heritage sites list obtained directly from the UN is considered to be the authoritative source for the location of these sites.
	Other products evaluated	None. This is the authoritative data source.
	Data product limitations	UNESCO provides a center point for a feature and the area of the site in hectares. No boundaries of sites are provided. A 2012 release of the UNESCO data which included boundaries indicated that boundaries were obtained from the WDPA,[*] which is also used in ENSITE in conjunction with this data.

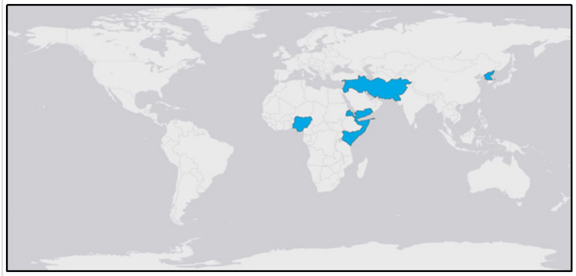
2.6.6 VISNAV land use/land cover

Data Overview	Product summary	NGA has several land use/land cover (LULC) products under the Visual Navigation (VISNAV) program since 2010.[†] Each product supports a variety of applications such as broad area search, cartographic vegetation mapping, vehicle mobility modeling, engineering planning, and humanitarian disaster response. The basic land cover product (LC) was developed using LandSat and has a resolution of 30 m. The dataset has 12 LULC classes.
	Product source	NGA via the CMB
	Update frequency	2015–2016. Static, although the research project is ongoing, producing higher-fidelity data.

[*] http://whc.unesco.org/en/news/853

[†] https://www.arcgis.com/home/item.html?id=bbeb2585b4704b67bf81d1744acbc55d

	Product coverage	Global with the exception of continental United States (CONUS). 
	Product resolution	30 m, with a 900-m² MMU
	Source format	Raster
	Source projection	WGS84
	Classification/ distro restrictions	None
Data Meaning and Context	Use within literature	No examples of data used in literature could be found, as this is a foundation dataset used in military work.
	Justification for source	The VISNAV LULC is a DoD-identified foundation layer for geospatial analysis. That means that this layer is used in the development of other products, and it is a data source with which the warfighter has familiarity and which may be familiar to other projects.
	Other products evaluated	There are additional products in this family. VISNAV high-definition (HD) was derived in 2015–2016 from a single RapidEye imager, 5m resolution, and has a 900-m² MMU (36 pixels). VISNAV HD was produced over 17 AOIs: Afghanistan, Lebanon, Djibouti,

		Nigeria, Eretria, North Korea, Gaza Strip, Pakistan, Iran, Somalia, Iraq, Syria, Israel, West Bank, Jordan, Yemen, and Kenya. 
	Data product limitations	None

2.6.7 World Database on Protected Areas

Data Overview		
	Product summary	The 2.6.7 World Database on Protected Areas (WDPA) is a comprehensive datasource of protected areas which is updated monthly. It is the most comprehensive global dataset of marine and terrestrial protected areas–including spatial data (polygon boundaries and points) and tabular information. The WDPA is a joint project between the United Nations Environment Programme (UNEP) and the International Union for Conservation of Nature (IUCN). The WDPA was established in 1981. The WDPA data structure and protocols were updated in 2015 to incorporate protected lands information from additional parities including private land conservation groups, local communities, and indigenous peoples. (Juffe-Bignoli et al. 2016).
	Product source	UNEP's World Conservation Monitoring Centre, via the Protected Planet site.*
	Update frequency	Monthly†

* https://www.protectedplanet.net/

† https://www.protectedplanet.net/c/frequency-of-update-of-the-wdpa

	Product coverage	Global
	Product resolution	N/A; data is polygon/point. Resolutions vary based on site.
	Source format	Shapefile-- polygon and point
	Source projection	The WDPA is supplied in a geographic co-ordinate system: WGS84. The Mollweide projection is used to calculate the "GIS Area" (GIS_AREA) and "marine GIS area" (GIS_M_AREA) fields in the WDPA attribute table (Juffe-Bignoli et al. 2016, 29).
	Classification/ distro restrictions	None
Data Meaning and Context	Use within literature	The reach of the WDPA is further enhanced by services developed by other parties, such as the Global Forest Watch[*] and the Digital Observatory for Protected Areas,[†] which provide decision makers with access to monitoring and alert systems that allow whole landscapes to be managed better.
	Justification for source	This data was selected because of its global coverage, monthly updates, and data governance structure.
	Other products evaluated	Evaluated OSM data and found that features present in both satellite imagery and WDPA were missing. As a result, WDPA was selected. Additionally, as a United Nations (UN) program, the WDPA contains the officially recognized boundaries for UNESCO environmental sites.
	Data product limitations	One limitation of the product is that the data is collected from a variety of sources. As of March 2017, the data in the WDPA was derived from over 500 sources. The user guide for the data (Juffe-Bignoli et al. 2016, 31) states "How data providers have digitized the boundaries of a

[*] http://www.globalforestwatch.org/

[†] http://dopa.jrc.ec.europa.eu/en

		protected area, at what scale, which references they have used to map areas in relation to administrative boundaries, coastline maps and/or landscape features (e.g., rivers or lakes) will have a great influence in the accuracy of the data." Additionally, while doing a visual test of the data, two areas appeared to be located in the wrong place.

3 Step-by-Step Instructions for ENSITE HUB

The steps provided in this chapter walk a user through the process of acquiring data and processing it through ENSITE HUB.

3.1 Step 1: Acquire the necessary tools

ENSITE HUB assumes that data to be processed is located within a folder called C:\ENSITE\Data. Using hat particular folder location ensures that the database is able to be called similarly across all computers. Users should make that folder if it does not exist on their computer. If desired, users can create the folder in any other location; however, if that option is used the file path for each tool in HUB would then need to be changed accordingly.

1. Download the ENSITE Hub toolbox and Base_Data. This toolbox is hosted through the Di2E program (Di2e.net). Access to this page is available to any person with a common access card (CAC) and can be found by searching for ENSITE. Alternatively, access to the page can be requested by emailing Juliana.M.Wilhoit@USACE.Army.mil. This site's pages include additional guides and videos of the ENSITE HUB tools.
2. Once its downloaded, unzip the base data folder and place it in the C:\ENSITE\Data folder.

A few folders may need to be created on the user's computer. The HUB's processes will be much easier if the following locations are used:

1. **Base_Data** with the path of: C:\ENSITE\Data\Base_Data
2. The **HUB Toolbox** should be placed in C:\ENSITE\Toolboxes
3. Create a desktop folder for downloading and unzipping all required data.

3.2 Step 2: Obtain the required data

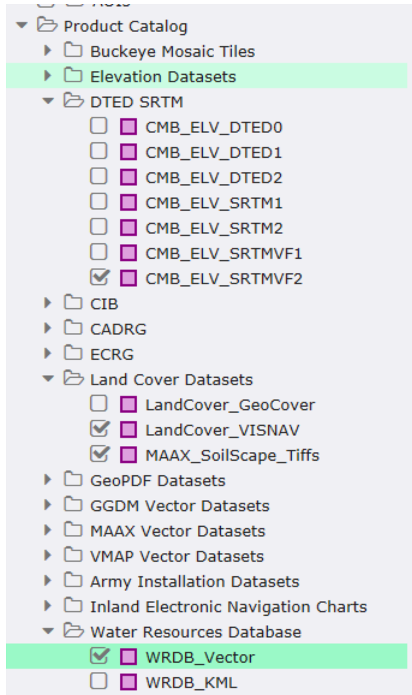
To acquire the data necessary to run basic ENSITE analyses, users must obtain various data from AGC's CMB, OSM, and Protected Planet. Below are the steps for how to collect this data for each AOI.

3.2.1 Elevation, soil, and land cover data from CMB

1. Navigate to CMB: https://agcwfs.agc.army.mil/CMB_Online
   a. Log in with your CAC and then choose email certificate option.
   b. A CMB Online help screen will pop up, which can be navigated to get more information. Choose "X" to close the help screen when done.
2. Create and then add an AOI to the cart by doing the following:
   a. Locate an area by going to Tools > Create AOIs > Search Gazetteer.
   b. **NOTE that by default, ENSITE selects data from within 15 km of the city center.
   c. An AOI can be created manually by drawing it, using one of the “create AOI” tools at left side of the screen.
3. Select the base data necessary for ENSITE. On the left side of the screen, navigate through the product catalog to select the datasets listed below. Right click on each and select “ADD SELECTED ITEMS TO CART.”
   a. DTED SRTM > **CMB_ELV_SRTMVF2**. This is Space Shuttle Radar Topography Mission Level 1, void-filled at a 1-arc second resolution. (1-arc second ~ 30 m).
   b. LandCover Datasets > **LandCover_VISNAV**
   c. LandCover Datasets > **MAXX_SOILSCAPE_TIFFs**
   d. Water Resources Database > **WRDB_Vector**

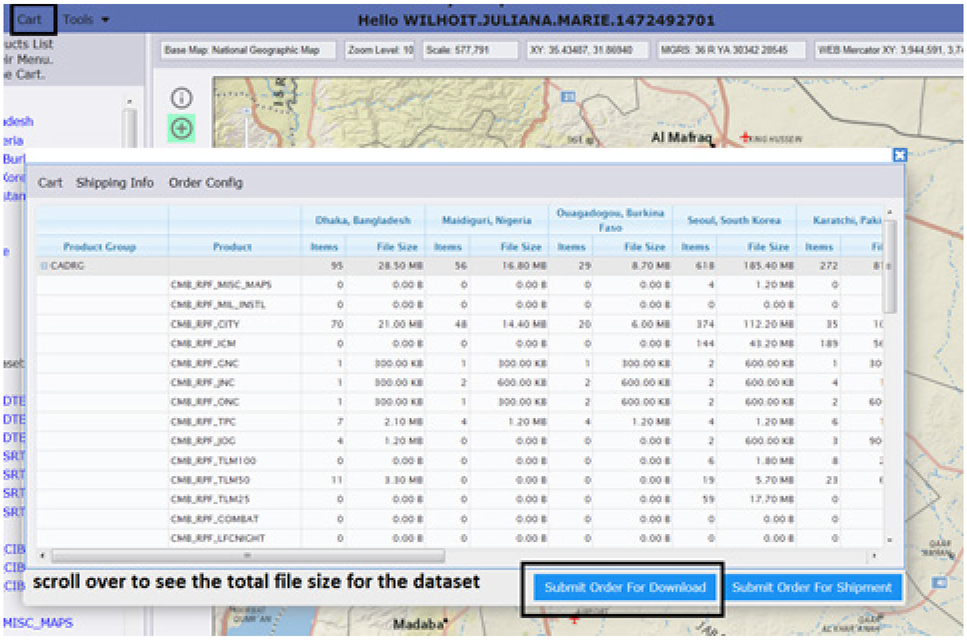
Figure 4 provides a screenshot with the appropriate items selected.

Figure 4. Screenshot of CMB product catalog with appropriated boxes checked.



4. Proceed to checkout by following the steps below. Figure 5 provides a screenshot of the checkout.
    a. Navigate to **Cart** (top bar).
    b. Review the order and see if it exceeds 40 GB. If it does, the order will be shipped via the mail. If the data is needed immediately, examine which files are the largest, remove them, and then complete two (or more) orders.
    c. Select the “Shipping Info” tab at the top of the page and type your shipment information. This information is required even if you are downloading data.
    d. Select the “Order Config” tab and accept the defaults.
    e. Select “Submit Order for Download.”

Figure 5. Screenshot of CMB cart.



5. Download the data.
   a. Users will receive an email with the subject line “CMB Download is ready.” Follow the link in the email to download requested data.
   b. Extract the data to the computer folder previously set up for all data. This location can be any folder on your computer.

3.2.2 Road data from Open Street Map

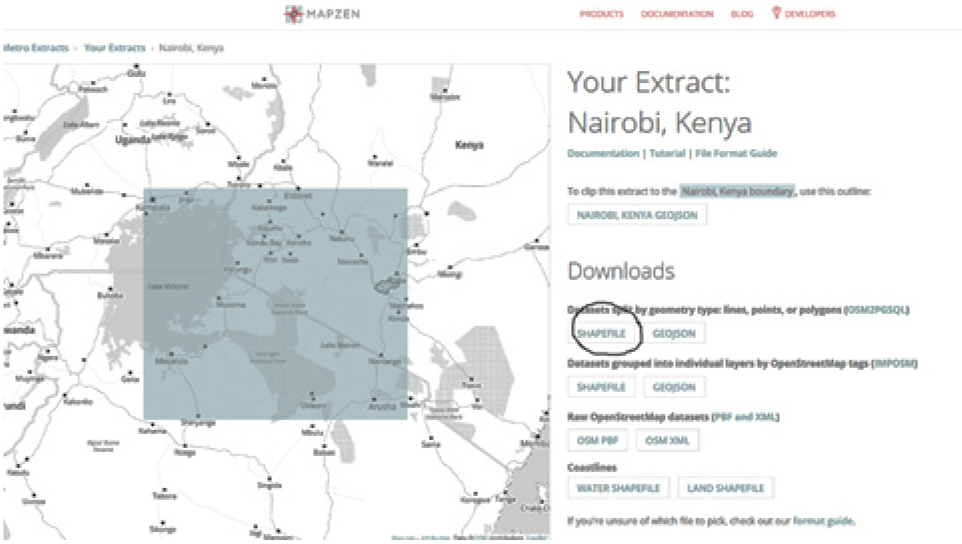
OSM data is a free and open-source dataset to which volunteers contribute data. The dataset is by no means comprehensive, but it has determined that it is sufficient for our needs and it is the best option that we have. There are many options for downloads of OSM data. For the moment, ENSITE is relying on a service which will easily extract the data for your needs, as described in the steps that follow.

1. Navigate to: https://mapzen.com/data/metro-extracts and search for the desired city. There may be two options for a city with a headings of "popular extracts ready for download now" or "to make a custom extract." If the desired city shows up under "popular extracts ready for download," great! Select it. And on the following page select to download SHAPEFILE in the OSM2PGSQL type. The pink box represents the area to be examined, so make sure the extent of the pink box includes the entire area to be examined. Figure 6 is a screenshot of this selection process in OSM.

Figure 6. Screenshot of OSM and selecting data for a geographic area.

2. **If there is not a ready extract available (indicated by a header of "create custom extract"),** drag the gray box over the map to the extent desired. Options of different levels may be given for an area, such as "local" or "regional." It does not matter which level is selected. Next, select the "GET EXTRACT" button. If that button is greyed out, the selected area is too large and multiple smaller requests will need to be submitted. To do that, simple change the selection box to be smaller, until the button is not greyed out. Make a mental note of the extents of the box (such as a city or feature bounding each city) and use that mark to begin an area for subsequent extracts.
    a. Next, the user will be directed to Git Hub, where sign-in is needed to complete the custom extract process. Thus it will be necessary to create an account if one does not already exist. It may take 30–60 minutes for the extract to be ready. Git Hub will send an email when it is done. Or you can refresh the page (https://mapzen.com/data/metro-extracts/your-extracts/). Figure 7 is a screenshot of the Git Hub data download page.
    b. Download and extract the data to the location you created.

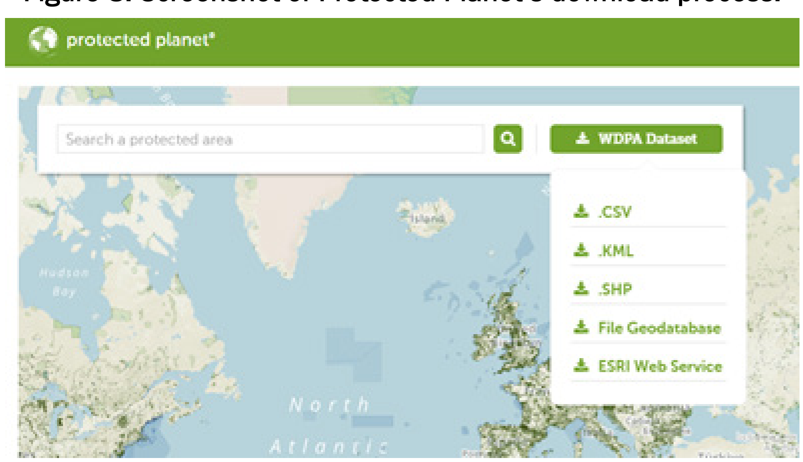
Figure 7. Screenshot of Git Hub to extract OSM datasets.



3.2.3 Cultural and heritage sites data from Protected Planet

1. Navigate to **Protected Planet**: https://www.protectedplanet.net/. Protected Planet is a program run by UNEP, and it contains data on natural areas around the world. The dataset is updated each month.
2. Search for the COUNTRY that the AOI is located in by selecting the magnifying glass.
3. This selection will bring up a page for the location being sought. Select the (generally first) option for your COUNTRY. Select the “Download this dataset” and select “.shp,” as illustrated in Figure 8. This selection should result in downloads of both polygon and point shapefiles.
4. Extract the WDPA Dataset point and polygon shapefiles files to the folder created for storing data.

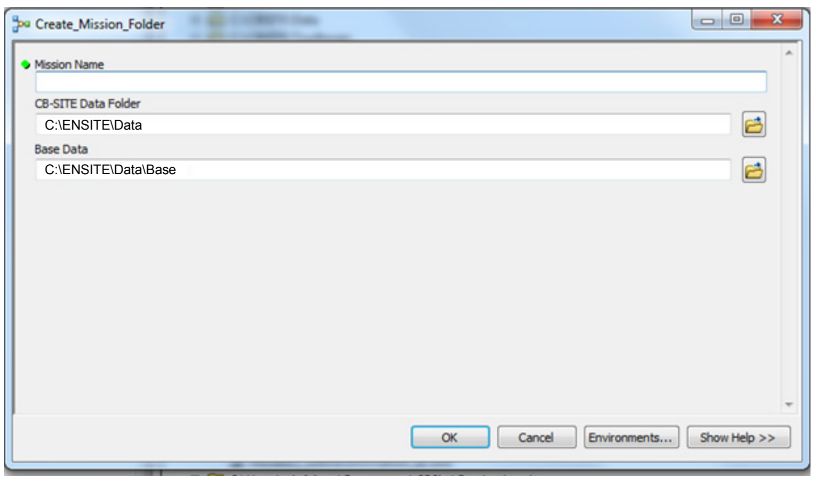
Figure 8. Screenshot of Protected Planet’s download process.



3.3 Step 3: Create the Mission Folder in ArcMap

1. First, connect to the toolbox (located in C:\ENSITE\Toolboxes). For more information on adding toolboxes visit the ArcGIS website.*
2. Then, the first step in populating a database is to create the Mission Folder. In the HUB toolbox, double click the model "Create_Mission_Folder".
3. The user inputs are the Mission Name and the start file locations, as illustrated in Figure 9. This assumes that the base data pulled from the s-drive is located in C:\ENSITE\Data\Base_Data, and that there is already a data folder located in C:\ENSITE\Data. If the paths do not already exist, they will need to be created or updated.

Figure 9. Screenshot of user entering the mission name in the Mission Folder.



3.4 Step 4: Load data into the geodatabase

Once the data is downloaded and the Mission Folder created, it is time to transform the data to look like GGDM data.

3.4.1 CMB data

1. After receiving the email with the link to download the data from CMB, choose >Download> Extract
2. In ArcMap, run the Convert_CMB_To_ENSITE tool from the ENSITE_HUB toolbox.

* http://pro.arcgis.com/en/pro-app/help/projects/connect-to-a-toolbox.htm

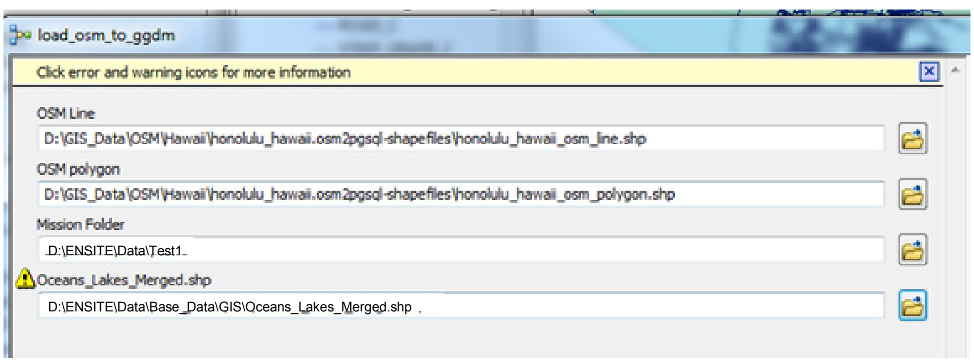
3. For the input called Raster Catalog, select the location of the raster catalog from the CBM download.

The above steps will need to be repeated for every dataset downloaded from CBM.

3.4.2 OSM data

Select the “Load_OSM_to_ggdm” tool from the “OSM_to_GGDM” toolset. Additionally, the tool relies on water body data from the World Wildlife Fund (WWF) and a separate OSM extract to get additional water information. The Oceans_Lakes_Merged.shp is located in the ENSITE base data folder. This data uses the OSM lines and polygons which were downloaded and extracted during an earlier step. Figure 10 provides a screenshot of this tool.

Figure 10. Screenshot of the ENSITE HUB tool “load_osm_to_ggdm”.



3.4.3 No-build cultural areas data

Use the “Create No Build Areas” within the “No_Build_Culture” toolset to extract cultural buffers and then place a 100 m buffer around them. Bulleted below are the inputs with descriptions of their purpose. Figure 11 provides a screenshot sample of entering the inputs.

- **OSM Point/ Line/ Polygon**. Link to the location on your computer for the point/ line/ polygon shapefiles.
- **Mission Folder** is the new folder created during this process in Step 1 (section 3.1).
- **UNESCO sites** do not need to be mapped to. UNESCO sites’ information is located in the base data on your computer and should be fine. This parameter is noted here only in the event that the ENSITE folder is not located on the user’s C-drive.

- **Protected Planet.** Provide the file path to both the point and polygon shapefiles for the Protected Planet data.

Figure 11. Screenshot of inputs to the “No_Build_Culture” ENSITE HUB tool.

4 Conclusion and Next Steps

The ENSITE project is novel, both as a product and process, for both the U.S. Army and the broader GIS defense solutions community. As of July 2017, ENSITE had developed eight versions of the core software, conducted over a dozen user engagement sessions, and partnered with two other major Army software development programs for deployed forces. The ENSITE HUB tool was developed initially as a simple tool to assist in speeding up some daily workflow tasks but then emerged as a core part of the ENSITE product. The ENSITE team has produced two major versions of the HUB tool, conducted a user jury, and now has a clear process for data governance.

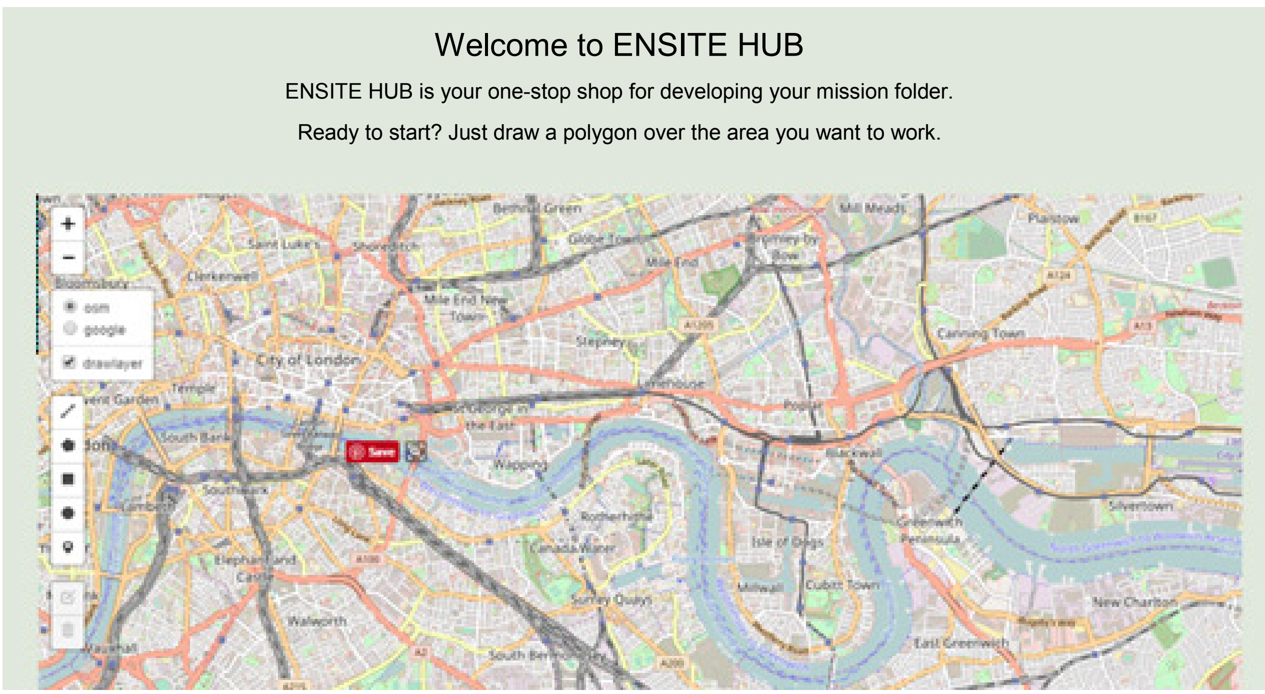
Feedback on ENSITE HUB was received February 2017, when the ENSITE data management team hosted a user jury, comprised of researchers at the Construction Engineering Research Laboratory, to receive feedback on ENSITE HUB's tools and workflow. The jury was comprised of seven participants ranging from an undergraduate student to a PhD holding researcher. Most of the jury members had minimal GIS background, and none had engaged with the ENSITE HUB tools prior to the event. The user jury event asked participants to go through the process of creating a Mission Folder for the area of Nairobi, Kenya. The jury users worked through the process, from acquiring the data to processing it into the Mission Folder.

These first-time users provided invaluable feedback to shape the future direction of the product. Overall, the feedback for improvement from the users was minor and related to clarifying language. Watching users use the ENSITE HUB tool showed that how users were not reading directions or utilizing all of the tools available to them (such as watching videos on the process). Furthermore, through watching users interact with the software and process, ENSITE researchers saw that the workflow was cumbersome. All users commented that it would have been easy to choose not to run the ENSITE HUB tool, either because they didn't value it or because they didn't see the need.

Based on that observation, the ENSITE research team determined that a new vision of ENSITE HUB was necessary. During the remaining years on the project, ENSITE HUB will rely less on users acquiring necessary data by collecting it from various websites. Instead, ENSITE HUB may become a server type of solution, where the required data is stored for the entire globe (with updates maintained as well). Figure 12 is an initial mock-up of the potential future ENSITE HUB, where a user simply draws a box on a screen to select an AOI and from there, the Mission Folder is created without further user effort or input.

Thus, significant work remains to transform ENSITE HUB from a cumbersome process to a more streamlined, automated process. Continued ENSITE research efforts will test the feasibility of future developments in the ENSITE HUB automated process.

Figure 12. Mockup of potential start page for ENSITE HUB Version 2.0.



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13. SUPPLEMENTARY NOTES

14. ABSTRACT

The current military environment means the U.S. Army needs the capability to strategically site contingency bases (CBs) for rapid response throughout a joint area of operations. To help with this need, the Army is funding work in the Engineering Site Identification for the Tactical Environment (ENSITE) program, which develops data and knowledge capabilities to assist decisions for CB site locations. Critical to the ENSITE program is the capability to integrate geospatial data elements in ways that broaden and improve military planners' understanding of the operating environment. To address this concern, ENSITE HUB is the set of tools developed for collecting, processing, and storing the various geospatial data required to execute ENSITE's analytical tools. The end product of the ENSITE HUB workflow is a mission folder, which is a transportable folder following a consistent structure. This report provides a temporal snapshot of the ENSITE HUB software and process.

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